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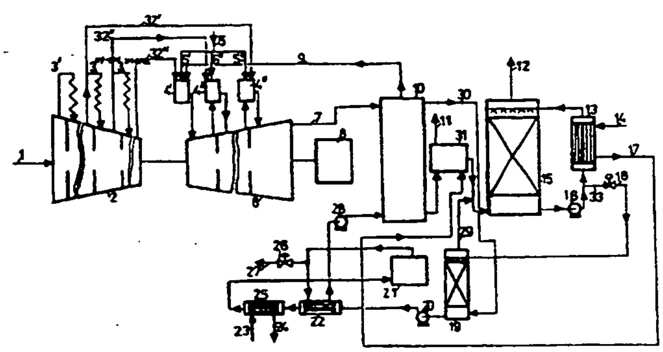

(57) Abstract

The method and the installation are intended to increase the energetic efficiency of gas-steam turbine at a simultaneous reduction of nitric oxides concentration in the flue gases. The invention could be applied in energetics. A characteristic feature of the method is that the gas-steam turbine is divided into stages, each of them with a combustor, as overheated water steam is transferred to the first stage of the turbine. After the turbine, the gas-steam mixture is passed to a heat exchanger for heat utilisation and for obtaining water steam required. Afterwards, the heat is additionally utilised to heat district heating water in a countercurrent heat exchanger and in a system of contact economisers, where the water steam condenses. The condensate is purified chemically and, after evaporating and overheating the steam, is passed to the first combustor. Air is transferred in stoichiometric amounts to the combustors, without the last one to which it is transferred in a small surplus. The burning temperature in the last combustor is lower. This leads to a significant reduction of nitric oxides concentration in the flue gases at a high process energetic efficiency. The installation includes multistage gas-steam turbine (6), equipped with combustors (4), air compressor (2), combined heat exchanger (10) for heating the products entering the combustors, heat exchanger (31) for heating district heating water, contact economisers (15), connected to pump (16) and heat exchanger block (13), as well as a column for purifying the water condensate from carbon dioxide and oxygen, heat exchangers (22 and 25), block for chemical purification of water condensate (21), and pumps (20 and 28).

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METHOD AND INSTALLATION WITH A GAS–STEAM TURBINE AND HEAT UTILIZATION

Field of the Invention

The invention relates to a method for heat utilization at burning of gaseous and liquid fuels for producing heat and mechanical energy and to an installation for its realization and will find an application mainly in energetic, especially in the production of electricity and heat energy for district heating purposes.

Description of the Prior Art

A method [1] for heat utilization of burning of gaseous and liquid fuels is known wherein fuels are burnt under high pressures in a combustor, as for the combustor, air and overheated water steam are also injected therein. The gas-steam mixture obtained is passed to the gas-steam turbine and then is cooled indirectly, thus its heat is used for obtaining overheated water steam that after overheating is passed to the combustor of the gas-steam turbine.

An installation [1] for realization of the method is known, that includes a gas-steam turbine, equipped with combustor, an air compressor and a boiler for obtaining overheated water steam connected to a pipe for injecting overheated water steam into the combustor.

A drawback of this method and of the installation of its realization is that the efficiency of converting the heat of fuel burning into mechanical energy and heat is not high enough and a significant portion of the water of the water steam passed to the combustor of the gas-steam turbine is loosed in the atmosphere together with the flue gases at the boiler outlet.

Technical Description

The aim of the invention is to develop a method that allows to increase the conversion of the heat transferred to the gas-steam turbine into mechanical energy produced in the installation at simultaneous complete utilization of the whole amount of heat passed with the fuel.

The invention is realized by a method for heat utilization of burning of gaseous and liquid fuels for producing mechanical and heat energy in an installation with a gas-

steam turbine. According this method, fuel burns under pressure in the combustor, as fuel, compressed air and water steam, mainly overheated, are passed to the combustor. The heated gas-steam mixture, after its passage through the gas-steam turbine, is cooled indirectly according to the countercurrent principle, wherein its heat is utilized for heating products entering the combustor. Characteristic feature of the method is that air and the fuel are passed for burning under pressure in one or more combustors of one or multistage gas-steam turbine. Water steam is passed mainly only to the first combustor working under highest pressure. To the other combustors, the gas-steam mixture, pre-treated in the previous stage of the gas-steam turbine, is passed for additional heating. The gas-steam mixture, additionally heated in a given combustor, is passed to the next stage of the gas-steam turbine. The gas-steam mixture is cooled indirectly after the final stage of the turbine, mainly by countercurrent, whereupon products entering to one or more combustors are heated. The primarily cooled gas-steam mixture is cooled additionally indirectly using countercurrent, mainly by means of preheated district heating water. Then, it is cooled additionally directly by countercurrent using not less than one circulating water flow heated by the gas-steam mixture, whereupon the water steam transferred to the first combustor as well as a part of the water steam produced during the fuel burning condense from the gas-steam mixture. After its final cooling the gas-steam mixture is thrown out into the atmosphere, whereas water condense is obtained.

According to a variant of the method, the coefficient of surplus air in the combustors is from 1.00 to 1.50, mainly from 1.00 to 1.10, as the lowest coefficient of surplus air, equal to 1 is characteristic mainly for the combustors of the gas-steam turbine stages, without the final one, whereas the highest coefficient is peculiar to the combustor of the final stage. The coefficient of surplus air is determined regarding the fuel passed totally to the whole combustors. The ratio of starting to final pressure in the stages of the gas-steam turbine varies from 1.3 to 20.0, mainly from 1.6 to 5.0 At the final stage it varies from 5 to 150, mainly from 10 to 30.

According to a second variant of the method, the gas-steam mixture, leaving the gas-steam turbine, indirectly heats a chemically purified water condensate, which is heated and evaporated The steam obtained is overheated, then entering the first combustor. The chemically purified water condensate is obtained treating the water condense, removed during direct heating of the gas-steam mixture, by countercurrent using water steam which heats it additionally and takes the dissolved oxygen and carbon dioxide away from the condensate. The gas-steam mixture obtained is mixed with the gas-steam mixture coming from the gas-steam turbine, mainly immediately after its last indirect cooling. The water condensate, free of carbon dioxide and oxygen, is cooled in series and indirectly, initially by means of chemically purified water and afterwards using cold water and then it is purified chemically from the traces of ions contained, thus

obtaining chemically purified water. Afterwards a portion of this water, obtained from the water condensate during the condensation of water steam, obtained at the fuel burning in the combustor, is removed from the system. The remaining chemically purified water is heated indirectly by water condensate, free of carbon dioxide and oxygen, and is passed for indirect heating, evaporation and overheating of the obtained water steam using the heat of the gas-steam mixture leaving the gas-steam turbine.

According to a third variant of the method, the gas-steam mixture, leaving the gas-steam turbine, in addition to chemically purified water which is evaporated as the obtained water steam is overheated, heats also compressed air as the products obtained after heating are passed to the corresponding combustors of the gas-steam turbine.

According to a fourth variant of the method, when regarding the heat balance, the heat of the gas-steam mixture is not sufficient to heat the products entering the combustors, additional heat, obtained during the fuel burning in a boiler, is added.

According to a fifth variant of the method, compressing of air for each N staged gas-steam turbine is achieved in a N1 staged compressor wherein N1 is higher or equal to N. At the inlet of the all stages of the compressor, without the first one, air is cooled, mainly indirectly, mainly by means of district heating water. Air required for fuel burning in the combustors is removed after each of the final N stages of the compressor, whereupon the ratio of the outlet pressure at a given compressor stage, without the stage before air entering the first combustor, to the inlet pressure at the given stage varies from 1.3 to 20.0, mainly from 1.6 to 5.0 as at the final stage, after which air enters the first combustor, this ratio varies from 5 to 150, mainly from 10 to 30.

According to a sixth variant of the method, compressing of air required for burning is achieved in two compressors, mainly multistage. The number of stages of the second compressor is equal to the number of combustors. The number of stages of the first compressor is lower by one Air enters the first stage under atmospheric pressure, whereas air after each stage of the first compressor is divided into two parts, afterwards the first one is cooled, mainly by means of district heating water, and is passed to the next stage of the first compressor. The other part is passed to the next, according its number, stage of the second compressor, as for example, after the first stage of the first compressor to the second stage of the second compressor. Air in the first stage of the second compressor is passed under atmospheric pressure. Air from the all stages of the second compressor enters the corresponding, according to pressure, combustors. Thus, the ratio of the outlet pressure at a given stage of the first compressor to the inlet pressure at this stage varies from 1.3 to 20, mainly from 1.6 to 5.0. For the second compressor this ratio is respectively from 5 to 150, mainly from 10 to 30.

According to a seventh variant of the method, in each compressor stage, without the last one, air is compressed at more than one substages. At each substage the ratio of

inlet to outlet pressure is mainly equal for each substages. After each substage, air is cooled mainly by means of district heating water.

According to an eighth variant of the method, each of the water streams cooling directly, in series, by countercurrent, previously indirectly cooled gas-steam mixture transfer their heat indirectly to another water stream, mainly district heating water. This is achieved according to the countercurrent principle. According to a ninth variant of the method, the water streams, without the last of them, that cool directly in series, by countercurrent, a previously indirectly cooled gas-steam mixture transfer their heat indirectly to another water stream, mainly district heating water_according to the countercurrent principle. The last water stream transfers, by direct countercurrent, its heat to air, entering for compressing to a compressor, thus humidifying it. Afterwards, the circulating water stream is passed back again to take away the heat of the gas-steam mixture. The method is applied by an installation with a gas-steam turbine for heat utilization of burning of gaseous and liquid fuels for producing mechanical and heat energy. The installation includes a gas-steam turbine and connected to its shaft a mechanical load, mainly an electricgenerator, as the gas-steam turbine is connected by means of a gas pipe for a gas-steam mixture to a heat exchanger for heat utilization from the gas-steam turbine for producing overheated water steam, as the gas-steam turbine is also connected to a combustor, which is connected to a fuel passing pipe, as it is connected also to a compressor by a compressed air pipe. The installation includes also a system for water steam condensation. A characteristic feature of the installation is that the gas-steam turbine is divided into N stages, each of them including one combustor. The space at the outlet of a given stage, without the last one, is connected by an intermediate gas pipe for a gas-steam mixture to the combustor at the following stage of the gas-steam turbine. \On the other hand, it is connected by means of a gas pipe for an additionally heated gas-steam mixture to its corresponding stage of the gas-steam turbine. Each combustor is also connected to a pipe for fuel passage and to a compressed air gas pipe. The gas-steam turbine is also connected by the first gas-steam mixture pipe to a heat exchanger for heat utilization from the gas-steam turbine for producing overheated water steam. This gas pipe is connected also by a second gas-steam mixture pipe to a countercurrent heat exchanger, mainly using ribbed pipes, as the last one is connected by a third gas-steam mixture pipe to the first contact economizer at the water steam condensation system. This system includes one or more, connected in series along the path of the gas-steam mixture, contact economisers. Furthermore, each contact economiser is countercurrent and contains packing and a liquid phase distributor and is connected at its bottom part by means of a first pipe for heated circulating water to a pump. This pump is connected by a second pipe for heated circulating water to a heat exchanger block, mainly countercurrent. This heat exchanger block is connected by the cooled circulation water pipe to the liquid phase distributor of the contact economiser,

and is also connected to a pipe for passing heated liquid, mainly district heating water, as well as to a pipe for passing the heated liquid. This pipe at the first, on the gas-steam mixture path, contact economiser is connected to a countercurrent heat exchanger that is connected also to a pipe for passing heated district heating water, whereas The second pipe for hot circulating water of the same first contact economiser that connects the pump to the heat exchanger block is connected also to a pipe for removing water condensate from the water steam condensing system. The final, on the gas-steam mixture path, contact economiser is also connected to the atmosphere by means of a gas pipe. The heat exchanger for the gas-steam mixture heat utilization after the gas-steam turbine, for obtaining overheated water steam is also connected by the steam pipe for overheated water steam to the first combustor.

According to a variant of the installation, the condensate removing pipe is divided into two parts, between which a regulating valve is connected in order to regulate the level of water condensate at the first, on the gas-steam mixture path, contact economiser. This pipe is also connected to the liquid phase distributor of a column for desorption of carbon dioxide and oxygen, mainly constructed as a packed column. This column by means of connected in series a first pipe for water condensate, a pump, and a second pipe for water condensate is connected to a heat exchanger for cooling water condensate by purified water condensate. This heat exchanger, on the other hand, by means of a third pipe for water condensate is connected to a heat exchanger for cooling water condensate by cooling water that by means of a fourth pipe for water condensate is connected to a block for chemical purification of water condensate. Furthermore, the heat exchanger for cooling water condensate by cooling water is also connected to a pipe for passing cooling water and to a pipe for removing heated cooling water. The block for chemical purification of water condensate is connected also by means of a first pipe for chemically purified water to the heat exchanger for cooling water condensate by chemically purified water. To the first pipe for chemically purified water, there are in series connected a first pipe for removing chemically purified water from the system, a regulating valve for regulation of the liquid level in the column for desorption of carbon dioxide and oxygen, and a second pipe for removing chemically purified water from the system. The heat exchanger for cooling water condensate by chemically purified water is also connected by means of the second pipe for chemically purified water to not less than one pump for increasing pressure of chemically purified water. This pump is connected also by a third pipe for chemically purified water to the heat exchanger for the gas-steam mixture heat utilization after the gas-steam turbine, for producing overheated water steam. This heat exchanger is connected by an water steam pipe to the column for desorption of carbon dioxide and oxygen. The column, on the other hand, is connected by means of a gas-steam mixture pipe to the gas-steam pipe after the countercurrent heat exchanger.

According to a second variant of the installation, the compressor is divided into N1 stages, from the first to N1, as the number of stages N1 is higher or equal to the number N of stages of the gas-steam turbine. The inlet of the first stage of the compressor is connected by means of a gas pipe for air under atmospheric pressure that is connected mainly to the atmosphere. The inlets of all other stages are connected by pipes for cooled air to heat exchangers for intermediate air cooling, mainly by means of district heating water. Each of these heat exchangers is connected by an air pipe for heated compressed air to the previous stage of the compressor. The last N air pipes for heated compressed air are connected also by means of second air pipes for heated compressed air. These air pipes are connected in a reverse order to the combustors of the gas-steam turbine.

According to a third variant of the installation, the second air pipes for heated compressed air, or a part of them, connecting the stages of the compressor to the corresponding combustors, before their connection to the combustors are divided into two parts. Heaters are included between them that are positioned in the combined heat exchanger for the gas-steam mixture heat utilization after the gas-steam turbine.

According to a fourth variant of the installation, the compressor consists of two separate compressors, a first and a second, mainly connected on a joint shaft with the gas-steam turbine. Each of them is divided into stages, as the number of the stages of the second compressor is N, which is equal to the number of the stages of gas-steam turbine. This number is by one more than that for the first compressor, where the stages are N-1. The inlets of the first stages of the compressors are connected by means of air pipes under atmospheric pressure. The outlet of each M stage of the first compressor is connected by means of an air pipe for compressed air to a corresponding intermediate heat exchanger that, on the other hand, is connected also by a pipe for cooled compressed air to M+ first stage of the second compressor. The outlet of all intermediate heat exchangers, without that at the last stage of first compressor, is connected also by means of a second pipe for cooled compressed air to the inlet of M+ first stage of first compressor. The outlets of all stages of the second compressor are connected by pipes for compressed air to the corresponding combustors of the gas-steam turbine in a reverse order. All intermediate heat exchangers are cooled mainly by district heating water.

According to a fifth variant of the installation, each stage of the compressor, respectively all stages of the first compressor at the variant with two compressor, is divided into two or more substages M1, where M1 is mainly two. The outlet of each substage, without the last, is connected in series by means of a pipe for hot air to a second heat exchanger for cooling, whereas it is connected to the next substage of the compressor. Moreover, the cooling fluid for the heat exchanger is mainly district heating water.

According to a sixth variant of the installation, in case when regarding the heat balance the heat of the gas-steam mixture at the inlet of the heat exchanger for the gas-steam mixture heat utilization after the gas-steam turbine is not sufficient to heat the products heated in it before their entering the combustors, the installation includes also a boiler, wherein additional fuel is burnt. In this case, the pipe for transferring steam from the heat exchanger, for the gas-steam mixture heat utilization after the gas-steam turbine, to the first combustor passes through the boiler before its entering the combustor, whereas the pipe for transferring steam to the column for removing carbon dioxide and oxygen from the water condensate is also connected to the boiler.

According to a seventh variant of the installation, a ventilator is connected to the gas pipe for removing the gas-steam mixture from the contact economiser.

The advantage of the invention is that it allows to increase the conversion of heat transferred to the gas-steam turbine into produced by the installation mechanical energy at a simultaneous complete utilization of the whole remaining amount of heat passed with the fuel, mainly for district heating purposes.

This advantage is a result of dividing the gas-steam turbine into stages with intermediate heating of the gas-steam mixture, in a manner providing its throttling down at high temperatures. The way of air compressing allows the compressor to spend a relatively low amount of energy produced by the gas-steam turbine, that allows its operating at higher pressures. Thus, the heat transferred for obtaining water steam is converted more completely into mechanical energy. The cooling of the heat exchangers by district heating water allows them, in fact, to work as thermo-pumps. This fact together with the condensation of water obtained during the fuel burning allow to increase the amount of heat energy obtained in the installation.

An additional advantage of the invention is that it guarantees a reduction of the final nitric oxides concentration in the gas-steam mixture after the gas-steam turbine. This advantage offers a possibility to carry out the process in all combustors, without the last one, with no air surplus, resulting in no production of nitric oxides in these combustors. The amount of carbon oxide obtained in these combustors is burnt in the last combustor of the gas-steam turbine, wherein due to the lower temperature of burning nitric oxides are practically not formed.

An additional advantage of the invention is that in the case of its application one can increase the ratio of mechanical energy, obtained at the shaft of the electricgenerator to the heat transferred to the combustors, that is previously passed through a heat exchanger wall. This fact allows to reduce the required heat transfer surface area. This advantage is related to the technological scheme of the compressor and, first of all, to its dividing into two parts, thus providing lower expenditure of mechanical energy for operating the compressor at high air temperatures at its outlet.

Brief Description of the Drawings

The invention is hereinafter described with reference to the accompanying drawings in which:

Fig. 1 is a principle technological scheme of the installation with a gas-steam turbine in which the compressor block consists of one compressor;

Fig. 2 is a principle technological scheme of the compressor block, with a gas-steam turbine, according to a variant of the invention in which the compressor is divided into two compressors;

Fig. 3 is a principle technological scheme of the compressor in which the stages of the first compressor are divided into substages with an intermediate air cooling between them;

Fig. 4 is a scheme showing the including an additional boiler to the installation.

Examples

According to an example of an embodiment of the invention, the installation in accordance with Fig. 1 includes compressor 2 for air required for the burning and gas-steam turbine 6 that is divided into N stages. The internal efficiency of both the gas-steam turbine and the compressors is 85 %. There are combustors 4, respectively $4'$, $4''$,...,4^N, at each stage. The space at the outlet of a given stage, without the last one, is connected by an intermediate gas pipe for a gas-steam mixture to combustor 4 at the following stage of gas-steam turbine 6. On the other hand, it is connected by means of a gas pipe for an additionally heated gas-steam mixture to its corresponding stage of gas-steam turbine 6. Each combustor 4 is also connected to pipe 5, respectively $5'$, $5''$,...,5^N, for fuel passage and to compressed air gas pipe 32, respectively $32'$, $32''$,...,32^N. The gas-steam turbine 6 is connected by first gas-steam mixture pipe to heat exchanger 10 for heat utilization from the gas-steam turbine for producing overheated water steam. This gas pipe is connected also by second gas-steam mixture pipe to countercurrent heat exchanger 31, mainly using ribbed pipes. The last one is connected by third gas-steam mixture pipe to first contact economiser at the water steam condensation system. This system includes one or more, connected in series along the path of the gas-steam mixture, contact economisers 15. Each contact economiser 15 is countercurrent and contains packing and a liquid phase distributor and is connected at its bottom part by means of first pipe for heated circulating water to pump 16. On the other hand, the pump is connected by second pipe for heated circulating water to heat exchanger block 13. This heat exchanger block is connected by the cooled circulation water pipe to the liquid phase distributor of contact economiser 15. It is also connected to pipe 14 for passing heated liquid, mainly district heating water, as well as to pipe 17 for passing the heated

liquid. The pipe 17 at the first, on the gas-steam mixture path, contact economiser 15 is connected to countercurrent heat exchanger 31 that is connected to pipe 11 for passing heated district heating water. The second pipe for hot circulating water of the same first contact economiser 15 that connects pump 16 to heat exchanger block 13 is connected also to pipe 33 for removing water condensate from the water steam condensing system. The final, on the gas-steam mixture path, contact economiser 15 is also connected to the atmosphere by means of gas pipe 12.

According to a variant of this example, when regarding the heat balance the heat of the gas-steam mixture after the gas-steam turbine is not sufficient to heat the products passed for heating to heat exchanger 10 for gas-steam heat utilization after the gas-steam turbine, this heat exchanger is also connected by means of a pipe to boiler 35 in accordance with Fig. 4. It is also connected by means of overheated steam pipe 9 to first combustor 4'. Condensate removing pipe 33 is divided into two parts, between which regulating valve 18 is mounted to regulate the water condensate level in the first, on the gas-steam mixture path, contact economiser 15. This pipe is also connected to the liquid phase distributor of column 19 for desorption of carbon dioxide and oxygen, mainly constructed as a packed bed column. Column 19 is connected by connecting, in series, first pipe for water condensate, pump 20, and second pipe for water condensate to heat exchanger 22 for cooling water condensate by chemically purified water. The last one by means of a third pipe for water condensate is connected to heat exchanger 25 for cooling water condensate by cooling water. Heat exchanger 25 by means of fourth pipe for water condensate is connected to block 21 for chemical purification of water condensate. This heat exchanger is also connected to pipe 23 for passing cooling water and to pipe 24 for removing heated cooling water. Block 21 for chemical purification of water condensate is connected also by means of first pipe for chemically purified water to heat exchanger 22 for cooling water condensate by chemically purified water. To the first pipe for chemically purified water, in series, there are connected first pipe for removing chemically purified water from the system, regulating valve 26 for regulation of the liquid level in column 19 for desorption of carbon dioxide and oxygen, and second pipe 27 for removing chemically purified water from the system. Heat exchanger 22 for cooling water condensate by chemically purified water is also connected by means of second pipe for chemically purified water to not less than one pump 28 for increasing pressure of chemically purified water. This pump is connected also by third pipe for chemically purified water to heat exchanger 10 for the gas-steam mixture heat utilization after gas-steam turbine 6. Boiler 35 is connected by means of pipe 30 to column 19 for desorption of carbon dioxide and oxygen. This column is also connected by means of gas-steam mixture pipe 29 to the gas-steam mixture pipe after countercurrent heat exchanger 31.

Compressor 2 is divided into N1 stages, respectively from first to N1. The first stage is connected by means of gas pipe 1 to the atmosphere. There are gas pipes for

heated compressed air at the outlet of each stage, as to each pipe, without the last one, heat exchangers 3, respectively 3', 3", 3^{N-1}, are connected for intermediate air cooling, mainly using district heating water. Each of heat exchangers 3 is connected by means of a pipe for cooled air to the next stage of compressor 2. The last N gas pipes for heated compressed air are connected also by second gas pipes for heated compressed air 32, respectively 32', 32",...,32^N, as these gas pipes are connected in a reverse order to combustors 4 of gas-steam turbine 6. All second gas pipes for heated compressed air 32 connecting the stages of compressor 2 to corresponding combustors 4, before their connecting to the combustors are divided into two parts, between which heaters are mounted that are located in heat exchanger 10 for the gas-steam mixture heat utilization after the gas-steam turbine.

The installation operates in the following manner. Overheated water steam at a temperature *tbk* is passed from boiler 35 to first combustor 4'. Natural gas is transferred to each of the combustors as its total amount is *Gch4* kgmol per one kgmol water steam. The amount of natural gas is dosed in such a way that the gas-steam mixture temperature after the combustor is *tt3*. Compressed air, in amount corresponding to the coefficient of surplus air equal to *Alfa*, is passed from compressor 2 to the combustors. Before its passing to combustors 4 of gas-steam turbine 6, air is heated to temperature *tbk* in heaters, located in heat exchanger 10 for gas-steam mixture heat utilization after gas-steam turbine 6. The pressure in first combustor 4' is equal to *P*. The values of the parameters according to the above mentioned denotations as well as those given below are presented in Table 1 for 19 separate numerical cases of the example. The fuel transferred to first combustor 4' is burnt in air, thus additionaly overheating the water steam added to the combustor. The ratio of outlet to inlet pressure for each compressor stage is one and the same for all stages and is equal to the ratio of inlet to outlet pressure for all stages of gas-steam turbine, without the last one. The outlet pressure is approximately equal to the atmospheric pressure. After reducing the pressure in the first stage of the gas-steam-turbine, the gas-steam mixture enters the combustor at its next stage. Here, the passed fuel burn burns in air, thus heating the added gas-steam mixture. The same is repeated for each following stage of the gas-steam turbine. After the last stage of the turbine, he outlet temperature is *tt41*. At this temperature the gas-steam mixture enters heat exchanger 10 for flue gases heat utilization. Chemically purified water is also passed to the heat exchanger where it is heated to the boiling temperature, and then is evaporated and overheated to temperature *tbk*. Air entering combustors 4 is heated in the same heat exchanger to the same temperature *tbk*. If the heat carried by the gas-steam mixture is not sufficient to obtain and overheat water steam and to heat air additional heat transferred to boiler 35 is used for heating. The overheated water steam from heat exchanger 10 and boiler 35 enters combustor 4'. The air heated in heat exchanger 10 is distributed between all combustors 4. The gas-steam mixture from heat

exchanger 10 enters for additional cooling countercurrent heat exchanger 31 for additional heating of previously heated district heating water. The temperature of the gas-steam mixture after heat exchanger 31 is 100 °C. At this temperature it enters contact economisers 15, where at the outlet of the last, on the gas path, contact economiser it is cooled to a temperature of 50 °C. At this temperature it is thrown out to the atmosphere through gas pipe 12. The cooling of the gas-steam mixture in contact economisers 15 is done during its scrubbing with circulating water transferred from the bottom of the apparatus by means of pump 16. The circulating water cooled in heat exchanger blocks 13 is passed again to the liquid phase distributors of contact economisers 15. Cooling of the heat exchangers is done by district heating water that in all numerical cases of the example is at initial temperature of 45 °C. The operation takes place according to the countercurrent principle. After the last of the heat exchanger blocks 13, the circulating water is heated to 71-85 °C and is overheated to 80-90 °C in heat exchanger 31. At this temperature it is removed from the system through pipe 11 for heated district heating water. The main portion of the water steam carried by the gas-steam mixture condenses in contact economisers 15, as in addition to the water steam transferred to combustor 4', additional water steam condenses in quantity equal to 0.4 kg per each kg natural gas passed to combustors 4 of the gas-steam turbine 6. The condensate obtained is removed through regulating valve 18 and is passed to column 19, where it is treated by water steam, transferred through pipe 30 from boiler 35. Approximately 99.9 % of oxygen as well as approximately 99.9 % of carbon dioxide contained in the water condensate are removed in the column. These substances together with the water steam surplus that is about 1 kg per ton of water condensate are added to the gas-steam mixture before its entering the first on the gas-steam mixture path contact economisers 15. The water condensate free of carbon dioxide and oxygen is cooled in heat exchangers 22 and 25 to a temperature of 30 °C, after which enters the block for chemical purification of water condensate 21. Here, it is finally purified from ions and leaves the block as chemically purified water. Portion of it, in a quantity of 0.4 kg per each kg of natural gas burnt in combustors 4 of gas-steam turbine 6 is removed from the installation through regulating valve 26 and pipe 27. The remaining chemically purified water enters heat exchanger 22 for cooling water condensate, and is heated to a temperature of 95-100 °C. Then, it enters heat exchanger 10 for gas-steam mixture heat utilization after gas-steam turbine 6, for heating, evaporating, and overheating of the steam obtained. After obtaining additional quantity of heat in boiler 35, it in the form of overheated water steam is passed to first combustor 4'.

Air, required for fuel burning is injected from the atmosphere in the first stage of compressor 2. The coefficient of surplus air, *Alfa*, for this case is equal for all combustors. After each stage, without the last one, air is cooled in heat exchangers 3, respectively 3', 3",...,3^{N1-1}. The cooled air after all heat exchangers from 3' to 3^{N1-N}, respectively is passed

to the next in order stages of the compressor. The air cooled in the other heat exchangers is divided into two parts, one is passed to the next stage of the compressor, and the other, after its heating in heat exchanger 10 enters the corresponding combustor 4. Air from the last compressor stage enters totally to the corresponding combustor after heating it in heat exchanger 10.

The following parameters are also presented in Table 1:

-Dkpdo- efficiency of the installation, determined on the base of lower operating heat of methane and the whole amount of heat obtained by the water steam in boiler 35.

-Dkpd1- the ratio of energy used for air compressing to the whole amount of energy obtained in gas-steam turbine 6.

-Dkpd2- the ratio of energy transferred to the shaft of the electricgenerator to energy transferred through the heat exchange surface area of combined heat exchanger 10 and boiler 35. It is assumed that water from which water steam is obtained is initially heated to 120 °C in the system with contact economisers and in the prior part of combined heat exchanger 10, consisting of ribbed pipes. At the point where the condensate is heated to 120 °C, the gas-steam mixture in combined heat exchanger 10 is cooled to 180 °C.

Dkpd3- energy passed with the fuel to the combustor related to the sum of energy passed with the fuel to the combustors of the gas-steam mixture and the heat transferred for overheating the water steam in boiler 35.

Table 1

Numerical cases	N	N1	Gch4	Alfa	P bar	tt3 C°	tbk C°	tt41 C°	Dpko %	Dpk1 %	Dpk2 %	Dpk3 %
1	1	4	0,0708	1,1	15	1200	550	648	31,23	34,79	42,08	66,26
2	1	4	0,0710	1,1	20	1200	550	603	31,76	36,23	44,45	64,21
3	2	4	0,0974	1,1	20	1200	550	719	47,15	14,79	70,78	78,38.
4	4	4	0,1627	1,1	20	1200	550	1014	47,52	10,55	83,93	100
5	1	4	0,0710	1,1	50	1200	550	475	32,05	41,09	49,43	58,94
6	2	4	0,1048	1,1	50	1200	550	604	50,91	16,80	87,21	74,04
7	4	4	0,1929	1,1	50	1200	550	961	53,79	11,36	110,1	100
8	3	5	0,1396	1,1	60	1200	550	656	55,33	17,30	107,5	82,5
9	3	6	0,1288	1,1	60	1200	550	601	51,8	20,92	98,45	77,97
10	4	6	0,1632	1,1	60	1200	550	719	57,01	16,93	114,0	89,26
11	2	5	0,1019	1,1	80	1200	550	520	47,90	22,96	85,32	69,00
12	3	5	0,1379	1,1	80	1200	550	657	55,26	17,23	106,1	81,86
13	4	6	0,1613	1,1	80	1200	550	769	56,95	16,84	112,6	88,65
14	4	6	0,1522	1,1	80	1200	600	721	56,70	16,40	106,2	85,50
15	4	5	0,1832	1,1	80	1200	550	800	60,19	16,40	122,0	97,60
16	4	4	0,2166	1,1	150	1200	550	974	55,5	12,62	129,0	100,0
17	5	5	0,2379	1,1	150	1200	550	982	52,9	13,12	128,0	100,0
18	5	7	0,1875	1,1	150	1200	550	975	58,13	16,59	121,2	95,85
19	5	6	0,2081	1,1	150	1200	550	856	58,24	14,73	126,4	100,0

According to a second example, that is also presented in Fig. 1 and Fig. 2, compressor 2 consists of two separate compressors 2 and 2' as shown in Fig. 2. The compressors are connected on a joint shaft to gas-steam turbine 6. Each of them is divided into stages, as the number of the stages of the second compressor 2' is N. This number is by one more than those of the first compressor 2, where they are N-1 and it is equal to the number of the stages of gas-steam turbine 6. The inlets of the first stages of the compressors are connected by means of air pipes 1 and 1' to the atmosphere. The outlet of each M stage of the first compressor 2 is connected by means of an air pipe for compressed air to a corresponding intermediate heat exchanger 3^{M}. This exchanger is connected also by a pipe for cooled compressed air to the M+ first stage of second compressor 2'. The outlet of all intermediate heat exchangers 3, respectively 3', 3",...,3^{N-1}, is connected also by means of a second pipe for cooled compressed air to the inlet of M+ first stage of first compressor 2 if it exists. The outlets of all stages of second compressor 2' are connected by pipes for compressed air 32, respectively 32', 32",...,32^{N}, to corresponding combustors 4 of gas-steam turbine 6 in a reverse order, as all intermediate heat exchangers 3 are cooled mainly by district heating water. According to a variant of this example, each stage of compressor 2 is divided into M1 substages. The outlet of each substage, without the last, is connected by means of a pipe for hot air to heat exchanger 34, respectively 34', 34",...,34^{M1-1} for cooling. This heat exchanger is connected to the next substage of compressor 2. The cooling fluid for heat exchangers (34) is district heating water.

The installation operates in the following manner. Overheated water steam is passed from heat exchanger 10 for gas-steam mixture heat utilization after the gas-steam turbine, or from boiler 35, when the heat of gas-steam mixture is not sufficient to obtain overheated water steam, to first combustor 4'. The temperature of steam is *tbk*. Natural gas is transferred to each of the combustors as its total amount is *Gch4* kgmol per one kgmol water steam. The amount of natural gas is dosed in such a way that the gas-steam mixture temperature after the combustor is *tt3*. Compressed air, in amount corresponding to the coefficient of surplus air equal to *Alfa* for all combustors, is passed from compressor 2' to the combustors. The pressure in first combustor 4' is equal to *P*, and in the last one to *P1*.

Air, required for fuel burning is passed through air pipes 1 and 1' from the atmosphere to the first stages of compressor 2 and compressor 2'. After all stages of compressor 2, without the last, air is divided into two parts. One of them after its cooling in corresponding heat exchanger 3 is passed to the next stage of compressor 2, and the other enters the corresponding stage of compressor 2'. Air from the last stage of compressor 2, after its cooling, enters totally the last stage of compressor 2'. Thus, the air from the first stage of compressor 2 enters the second stage of compressor 2', etc. The air compressed in the separate stages of compressor 2' enters the corresponding combustors,

namely, from the first stage of compressor 2' to Nth combustor, from the second stage of compressor 2' to N-1,..., and from the Nth to the first combustor. According to the variant of the example, wherein each stage of compressor 2 is divided into M1 substages, from all substages of compressor 2, without the last substages, the air is removed and cooled in heat exchangers 34, respectively 34', 34",...,34^{M1}, and then is passed to the next substage. All remaining operational details of the installation are the same as those for the first example.

The values of the parameters for the above mentioned denotations for 23 separate numerical cases of this example are presented in Table 2. The values not specified in this example are the same as those for the first example.

Table 2

Numeri-cal cases	N	M1	Gch4	Alfa	P bar	P1 bar	tt3 C°	tbk C°	tt41 C°	Dpko %	Dpk1 %	Dpk2 %	Dpk3 %
1	1	1	0,0644	1,1	15	-	1200	550	645	41,5	20,07	179	69,37
2	1	1	0,0459	1,1	15	-	1100	550	584	38,1	18,44	212	57,36
3	1	1	0,0364	1,1	15	-	1000	550	521	34,9	16,4	226	45,73
4	1	1	0,0620	1,1	20	-	1200	550	574	42,6	21,07	171	65,67
5	1	1	0,0644	1,1	50	-	1200	550	476	44,8	24,55	157	56,35
6	1	1	0,0515	1,1	80	-	1200	550	421	45,2	26,63	153	52,79
7	1	1	0,1713	1,1	150	-	1200	550	355	45,6	30,12	151	49,36
8	2	1	0,1418	1,1	150	15	1200	550	627	55,6	26,23	78	93,32
9	2	2	0,1389	1,1	150	15	1200	550	628	56,5	25,63	78,1	92,81
10	3	2	0,1571	1,1	150	15	1200	550	625	58,8	26,03	68,4	95,66
11	4	2	0,1570	1,1	150	15	1200	550	624	59,7	26,65	64,6	96,86
12	5	2	0,1713	1,1	150	15	1200	550	623	60 9	26,87	62,5	92,81
13	4	1	0,1873	1,1	200	15	1200	550	622	60 1	27,76	57,5	100,0
14	3	2	0,1873	1,1	200	15	1200	550	622	60 7	27,31	58,05	99,68
15	2	1	0,1691	1,1	300	15	1200	550	618	56,0	29,22	60,45	99,48
16	4	1	0,2171	1,1	300	15	1200	550	619	58,7	28,90	48,75	100,0
17	4	2	0,2130	1,1	300	15	1200	550	619	59,9	28,36	49,10	100,0
18	6	1	0,2045	1,1	300	20	1200	550	574	60,5	30,03	49,48	98,54
19	6	2	0,2008	1,1	300	20	1200	550	574	60,5	30,03	49,85	98,51
20	6	1	0,1828	1,0	300	20	1200	550	580	61,1	27,63	53,67	96,50
21	6	1	0,2583	1,2	300	20	1200	550	577	58,08	29,42	41,00	99,05
22	6	1	0,1754	1,1	300	20	1100	550	523	57,14	28,46	57,40	92,78
23	6	2	0,2107	1,1	300	20	1200	600	579	60,12	28,15	50,50	97,09

Claims

1. Method for heat utilization of burning of gaseous and liquid fuels for producing mechanical and heat energy in an installation with a gas-steam turbine wherein fuel burns under pressure in the combustor as fuel, compressed air and water steam, mainly overheated, are passed to the combustor as the heated gas-steam mixture, passed through the gas-steam turbine, is then cooled indirectly according to the countercurrent principle, wherein its heat is utilised for heating products entering the combustor, characterised by passing air and fuel for burning under pressure in one or more combustors of one or multistage gas-steam turbine wherein water steam is passed mainly only to the first combustor working under highest pressure whereas to the other combustors the gas-steam mixture, pre-treated in the previous stage of the gas-steam turbine, is passed for additional heating, thereafter the gas-steam mixture, additionally heated in a given combustor, is passed to the corresponding stage of the gas-steam turbine, as the gas-steam mixture is cooled indirectly after the final stage of the turbine, mainly by countercurrent, whereupon products entering to one or more combustors are heated as the primarily cooled gas-steam mixture is cooled additionally indirectly using countercurrent, mainly by means of preheated district heating water and thereafter it is cooled additionally directly by countercurrent using not less than one circulating water flow heated by the gas-steam mixture, whereupon the water steam transferred to the first combustor as well as a part of the water steam produced during the fuel burning condense from the gas-steam mixture which after its final cooling is thrown out into the atmosphere whereas water condensate is obtained.

2. Method, according to Claim 1, characterised by a coefficient of surplus air in the combustors from 1.00 to 1.50, mainly from 1.00 to 1.10, as the lowest coefficient of surplus air, equal to 1 is characteristic mainly for the combustors of the gas-steam turbine stages, without the final one, whereas the highest coefficient is peculiar to the combustor of the final stage, thus the ratio of starting to final pressure in the stages of the gas-steam turbine varies from 1.3 to 20.0, mainly from 1.6 to 5.0, as at the final stage it varies from 5 to 150, mainly from 10 to 30.

3. Method, according to Claims 1 and 2, characterised by the fact that the gas-steam mixture, leaving the gas-steam turbine, heats a chemically purified water condensate, which is heated and evaporated, whereas the steam obtained is overheated, then entering the first combustor, as the chemically purified water condensate is obtained treating the water condensate, removed during direct heating of the gas-steam mixture, by countercurrent using water steam which heats it additionally and takes the dissolved oxygen and carbon dioxide away from the condensate, as the gas-steam mixture obtained is mixed with the gas-steam mixture coming from the gas-steam turbine, mainly immediately after its last indirect cooling, whereas the water condensate, free of carbon

dioxide and oxygen, is cooled in series and indirectly, initially by means of chemically purified water and afterwards using cold water, then it is purified chemically from the traces of ions contained, thus obtaining chemically purified water, afterwards a portion of this water, obtained from the water condensate during the condensation of water steam, obtained at the fuel burning in the combustor, is removed from the system, whereas the remaining chemically purified water is heated indirectly by water condensate, free of carbon dioxide and oxygen, and is passed for indirect heating, evaporation and overheating of the obtained water steam using the heat of the gas-steam mixture leaving the gas-steam turbine.

4. Method, according to Claim 3, characterised by the fact that the gas-steam mixture, leaving the gas-steam turbine, in addition to chemically purified water which is evaporated as the obtained water steam is overheated, heats also compressed air as the products obtained after heating are passed to the corresponding combustors of the gas-steam turbine.

5. Method, according to Claims 3 and 4, characterised by the fact that when regarding the heat balance the heat of the gas-steam mixture is not sufficient to heat the products entering the combustors, additional heat, obtained during the fuel burning in a boiler, is passed.

6. Method, according to Claims 3 and 5, characterised by the fact that compressing of air for each N staged gas-steam turbine is achieved in a N1 staged compressor wherein N1 is higher or equal to N, as at the inlet of the all stages of the compressor, without the first one, air is cooled, mainly indirectly, mainly by means of district heating water, whereas air required for fuel burning in the combustors is removed after each of the final N stages of the compressor, whereupon the ratio of the outlet pressure at a given compressor stage, without the stage before air entering the first combustor, to the inlet pressure at the given stage varies from 1.3 to 20.0, mainly from 1.6 to 5.0 as at the final stage, after which air enters the first combustor, this ratio varies from 5 to 150, mainly from 10 to 30.

7. Method, according to Claims 3 and 5, characterised by the fact that compressing of air required for burning is achieved in two compressors, mainly multistage, as the number of stages of the second compressor is equal to the number of combustors, whereas the number of stages of the first compressor is lower by one, as air enters the first stage under atmospheric pressure, whereas air after each stage of the first compressor is divided into two parts, afterwards the first one is cooled, mainly by means of district heating water, and is passed to the next stage of the first compressor, whereas the other part is passed to the next, according its number, stage of the second compressor, as for example, after the first stage of the first compressor to the second stage of the second compressor, as air in the first stage of the second compressor is passed under atmospheric pressure, whereas air from the all stages of the second

compressor enters the corresponding, according to pressure, combustors, whereupon the ratio of the outlet pressure at a given stage of the first compressor to the inlet pressure at this stage varies from 1.3 to 20, mainly from 1.6 to 5.0, whereas for the second compressor this ratio is respectively from 5 to 150, mainly from 10 to 30.

8. Method, according to Claim 6, characterised by the fact that in each compressor stage, without the last one, air is compressed at more than one substages, whereupon at each substage the ratio of inlet to outlet pressure is mainly equal for each substages, as after each substage air is cooled, mainly by means of district heating water.

9. Method, according to Claim 7, characterised by the fact that in each stage of the first compressor air is compressed at more than one substages as at each substage the ratio of inlet to outlet pressure is mainly equal for each substages, as after each substage air is cooled, mainly using district heating water.

10. Method, according to Claims 6 and 7, characterised by the fact that each of the water streams cooling directly, in series, by countercurrent, previously indirectly cooled gas-steam mixture transfer their heat indirectly to another water stream, mainly district heating water following the countercurrent principle.

11. Method, according to Claims 6 and 7, characterised by the fact that the water streams, without the last of them, that cool directly in series, by countercurrent, a previously indirectly cooled gas-steam mixture transfer their heat indirectly to another water stream, mainly district heating water according to the countercurrent principle, as the last water stream transfers, by direct countercurrent, its heat to air, entering for compressing to a compressor, thus humidifying it, afterwards the circulating water stream is passed back again to take away the heat of the gas-steam mixture.

12. An installation with a gas-steam turbine for heat utilization of burning of gaseous and liquid fuels for producing mechanical and heat energy including a gas-steam turbine and connected to its shaft a mechanical load, mainly electricgenerator, as the gas-steam turbine is connected by means of a gas pipe for a gas-steam mixture to a heat exchanger for heat utilization from the gas-steam turbine for producing overheated water steam, as the gas-steam turbine is also connected to a combustor, which is connected to a fuel passing pipe, as it is connected also to a compressor by a compressed air pipe, whereas the installation includes also a system for water steam condensation, characterised by the fact that the gas-steam turbine (6) is divided into N stages, each of them including one combustor (4), respectively (4', 4",...,4^N), whereas the space at the outlet of a given stage, without the last one, is connected by an intermediate gas pipe for a gas-steam mixture to combustor (4) at the following stage of gas-steam turbine (6) that is connected by means of a gas pipe for an additionally heated gas-steam mixture to its corresponding stage of gas-steam turbine (6), as each combustor (4) is also connected to pipe (5), respectively (5', 5",...,5^N), for fuel passage and to compressed air gas pipe (32),

respectively (32', 32",...,32^{N}), as these gas pipes are connected in a reverse order to combustors (4) of gas-steam turbine (6), namely (32') to (4^{N}), (32") to (4^{N-1}) ... and (32^{N}) to (4'), whereas gas-steam turbine (6) is connected by first gas-steam mixture pipe to heat exchanger (10) for heat utilization from the gas-steam turbine for producing overheated water steam, as this gas pipe is connected also by second gas-steam mixture pipe to countercurrent heat exchanger (31), mainly using pipes with ribs, as the last one is connected by third gas-steam mixture pipe to first contact economiser at the water steam condensation system that includes one or more, connected in series along the path of the gas-steam mixture, contact economisers (15), in addition, each contact economiser (15) is countercurrent and contains packing and a liquid phase distributor and is connected at its bottom part by means of first pipe for heated circulating water to pump (16) that is connected by second pipe for heated circulating water to heat exchanger block (13), mainly countercurrent, as heat exchanger block (13) is connected by the cooled circulation water pipe to the liquid phase distributor of contact economiser (15), and is also connected to pipe (14) for passing heated liquid, mainly district heating water, as well as to pipe (17) for passing the heated liquid, as this pipe (17) at the first, on the gas-steam mixture path, contact economiser (15) is connected to countercurrent heat exchanger (31) that is connected to pipe (11) for passing heated district heating water, whereas second pipe for hot circulating water of the same first contact economiser (15) that connects pump (16) to heat exchanger block (13) is connected also to pipe (33) for removing water condensate from the water steam condensing system, as the final, on the gas-steam mixture path, contact economiser (15) is also connected to the atmosphere by means of gas pipe (12), as heat exchanger (10) for heat utilization of the gas-steam mixture after the gas-steam turbine (6) is also connected by steam pipe (9) for overheated water steam to combustor (4').

13. An installation, according Claim 12, characterised by the fact that the condensate removing pipe (33) is divided into two parts, between which regulating valve (18) is connected to regulate the level of water condensate at the first, on the gas-steam mixture path, contact economiser (15) and is also connected to a liquid phase distributor of column (19) for desorption of carbon dioxide and oxygen, mainly constructed as a packed column that by connected in series first pipe for water condensate, pump (20), and second pipe for water condensate is connected to heat exchanger (22) for cooling water condensate by purified water condensate, as the later by third pipe for water condensate is connected to heat exchanger (25) for cooling water condensate by cooling water that by means of fourth pipe for water condensate is connected to block (21) for chemical purification of water condensate, as heat exchanger (25) for cooling water condensate by cooling water is also connected to pipe (23) for passing cooling water and to pipe (24) for removing heated cooling water, whereas block (21) for chemical purification of water condensate is connected also by means of first pipe for chemically

purified water to heat exchanger (22) for cooling water condensate by chemically purified water, as to the first pipe for chemically purified water, in series there are connected first pipe for removing chemically purified water from the system, regulating valve (26) for regulation of the liquid level in column (19) for desorption of carbon dioxide and oxygen, and second pipe (27) for removing chemically purified water from the system, whereas heat exchanger (22) for cooling water condensate by chemically purified water is also connected by means of second pipe for chemically purified water to not less than one pump (28) for increasing pressure of chemically purified water that is connected also by third pipe for chemically purified water to heat exchanger (10) for the gas-steam mixture heat utilization after gas-steam turbine (6), as heat-exchanger (10) for the gas-steam mixture heat utilization after gas-steam turbine (6) is connected by pipe (30) to column (19) for desorption of carbon dioxide and oxygen, that is connected by means of gas-steam mixture pipe (29) to the gas-steam pipe after countercurrent heat exchanger (31).

14. An installation, according to Claims 12 and 13, characterised by the fact that compressor (2) is divided into N1 stages, as N1 is higher or equal to the number of stages of the gas-steam turbine, as the inlet of the first stage of compressor (2) is connected by means of gas pipe (1) for air under atmospheric pressure, connected mainly to the atmosphere, whereas the inlets of all other stages are connected by pipes for cooled air to heat exchangers (3), respectively ($3'$, $3''$,...,3^{N-1}), for intermediate air cooling, mainly by means of district heating water, as each of heat exchangers (3) is connected by an air pipe for heated compressed air to the previous stage of compressor (2), as the last N air pipes for heated compressed air are connected also by means of second air pipes for heated compressed air (32), respectively ($32'$, $32''$,...,32^{N}), as these air pipes are connected in a reverse order to combustors (4) of gas-steam turbine (6).

15. An installation, according to Claim 14, characterised by the fact that the second air pipes for heated compressed air (32), respectively ($32'$,...,32^{N}), or a part of them, connecting the stages of compressor (2) to the corresponding combustors (4), before their connection to the combustors are divided into two parts, as heaters are included between them, positioned in heat exchanger (10) for the gas-steam mixture heat utilization after the gas-steam turbine.

16. An installation, according to Claims 12 and 13, characterised by the fact that compressor (2) consists of two separate compressors (2) and (2'), mainly connected on a joint shaft with gas-steam turbine (6), as each of them is divided into stages, as the number of the stages of the second compressor (2') is N, one more than those of the first compressor (2), where they are N-1 and it is equal to the number of the stages of gas-steam turbine (6), as the inlets of the first stages of the compressors are connected by means of air pipes (1) and (1') under atmospheric pressure, whereas the outlet of each M stage of the first compressor (2) is connected by means of an air pipe for compressed air

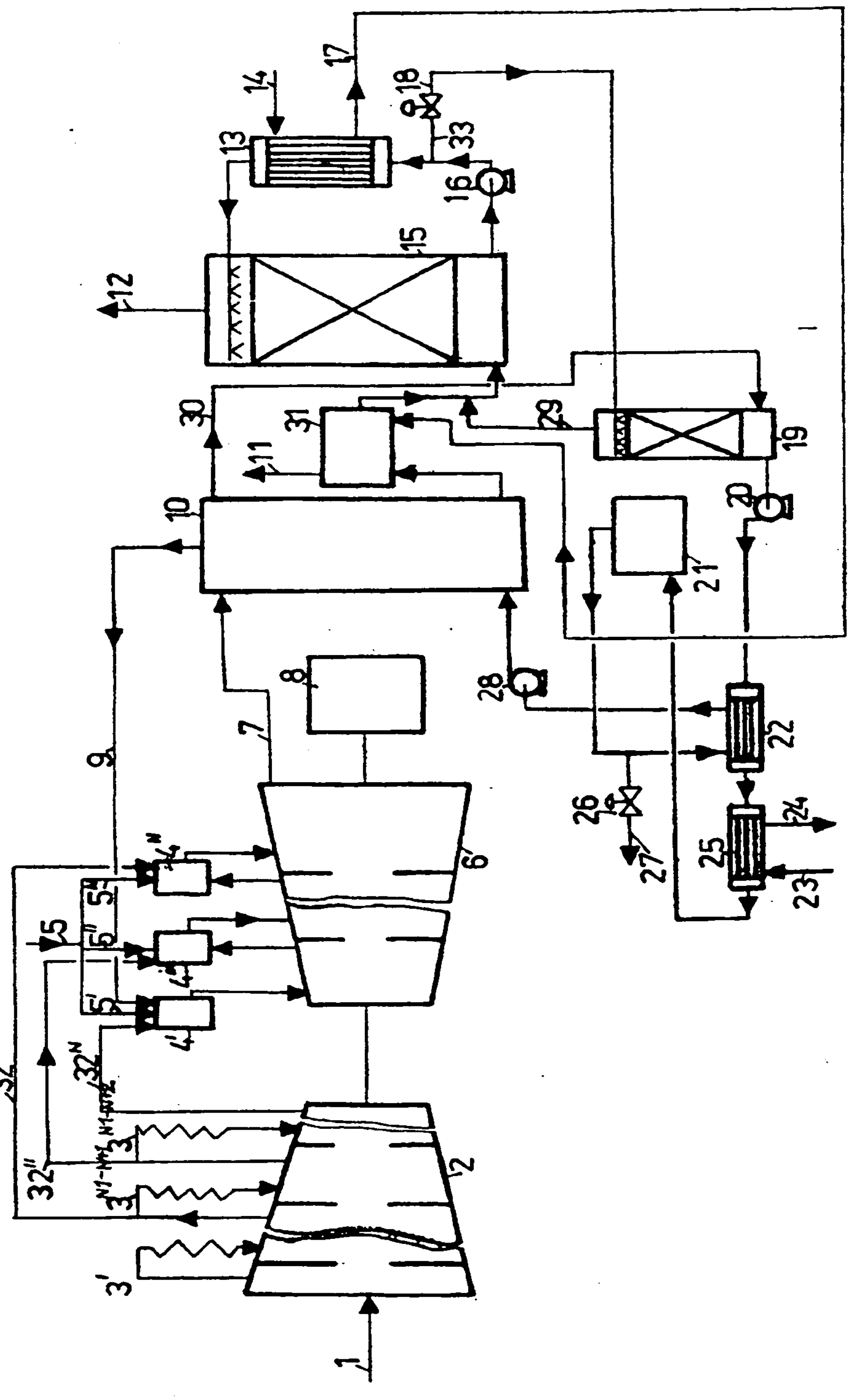
to a corresponding intermediate heat exchanger (3^M), that is connected also by a pipe for cooled compressed air to M+ first stage of second compressor (2'), as the outlets of all intermediate heat exchangers (3), respectively ($3', 3'',...,3^{N-1}$), without that at the last stage of first compressor (2), is connected also by means of a second pipe for cooled compressed air to the inlet of M+ first stage of first compressor (2), whereas the outlets of all stages of the second compressor (2') are connected by pipes for compressed air (32), respectively ($32', 32'',...,32^N$), to corresponding combustors (4) of gas-steam turbine (6) in a reverse order, as all intermediate heat exchangers (3) are cooled mainly by district heating water.

17. An installation, according to Claims 14 and 16, characterised by the fact that each stage of compressor (2) is divided into two or more substages M1, where M1 is mainly two, as the outlet of each substage, without the last, is connected in series by means of a pipe for hot air to heat exchanger (34), respectively ($34', 34'',...,34^{M1-1}$) for cooling, whereas it is connected to the next substage of compressor (2), as the cooling fluid for heat exchanger (34) is mainly district heating water.

18. An installation, according to Claim 13, characterised by the fact that in case when regarding the heat balance the heat of the gas-steam mixture at the inlet of heat exchanger (10) for the gas-steam mixture heat utilization after gas-steam turbine (6) is not sufficient to heat the products heated in it before their entering the combustors, includes also boiler (35), wherein additional fuel is burnt, as in this case pipe (9) for transferring steam from heat exchanger (10) to combustor (4') passes through boiler (35) before its entering combustor (4'), whereas pipe (30) for transferring steam to column (19) is also connected to boiler (35).

Literature

1. Patent of the Russian Federation, RU 2042847, July, 7, 1993.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3'
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32'
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32N
33

FIG.1

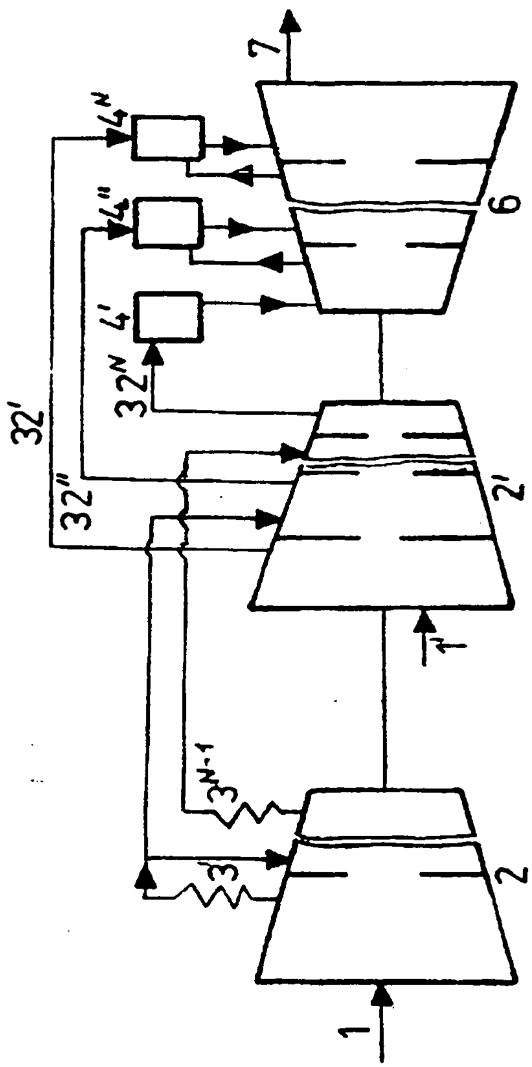

FIG. 2

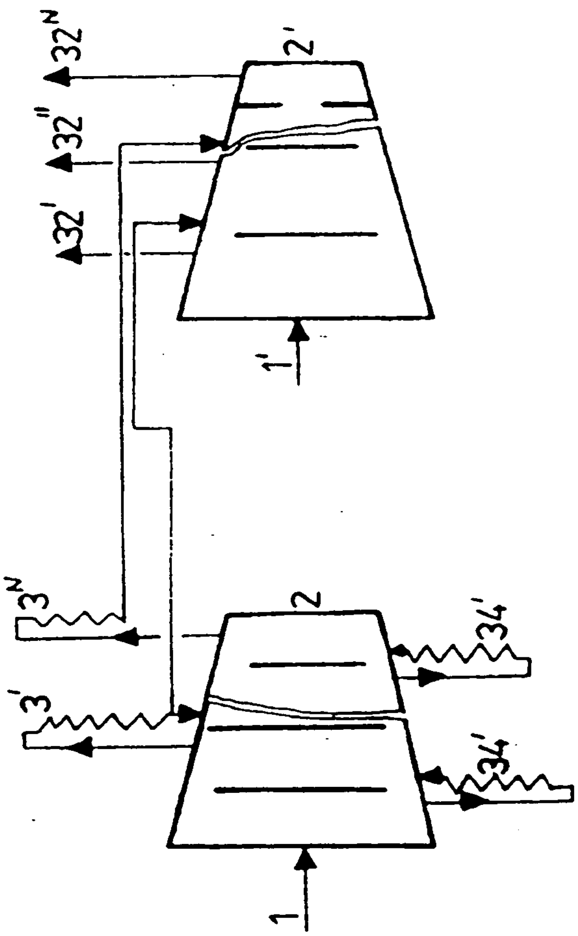

FIG.3

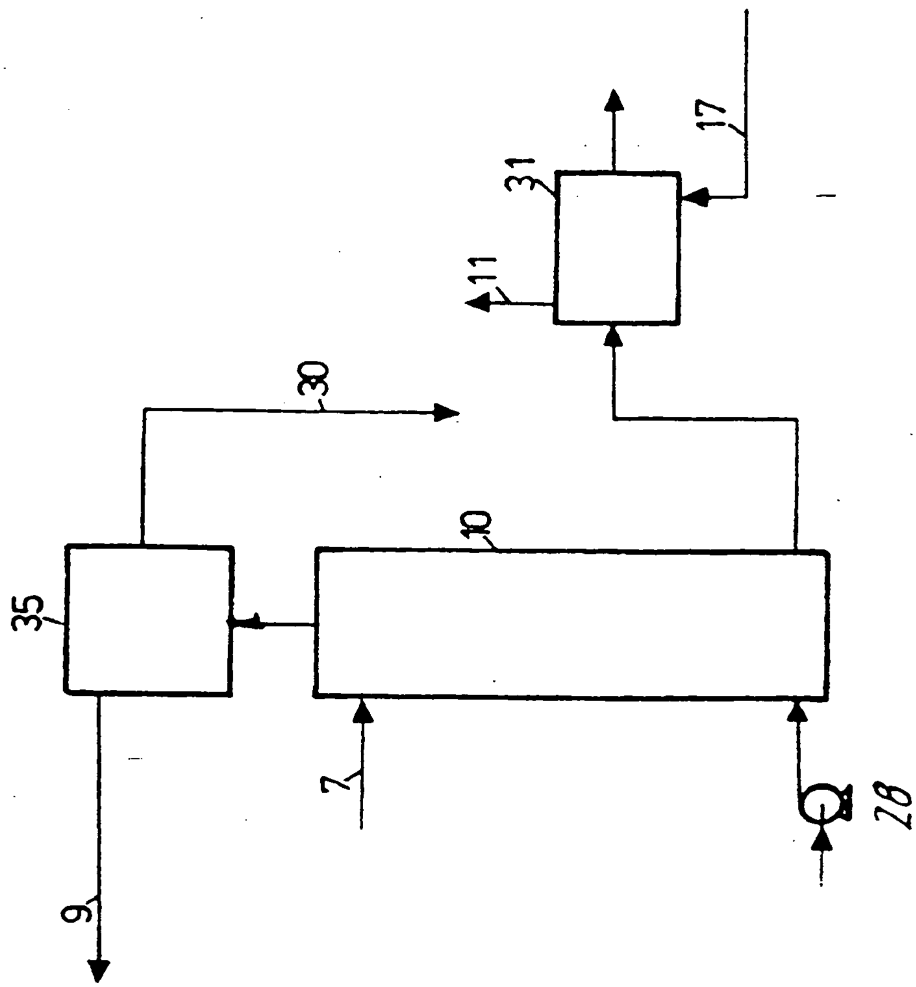

FIG.4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/BG 98/00004

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F01K21/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F01K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	"ADDING A CONDENSING HEAT EXCHANGER" POWER, vol. 136, no. 3, 1 March 1992, NEW YORK US, pages 82-83, XP000260670 see page 82, middle column, paragraph 3 - page 83, left-hand column, paragraph 2; figure 1	1,12
Y	GB 1 212 511 A (ATOMIC ENERGY) 18 November 1970 see the whole document	1,12
A	US 2 678 531 A (MILLER) 18 May 1954 see figure 3	1
A	GB 1 284 335 A (ROLLS-ROYCE) 9 August 1972	

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[X] Further documents are listed in the continuation of box C

[X] Patent family members are listed in annex.

* Special categories of cited documents :

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Date of the actual completion of the international search	Date of mailing of the international search report
19 June 1998	26/06/1998

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INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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Information on patent family members

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